

STS-13

Flight Requirements Document

Level A Groundrules and Constraints

Operational Flight Profile
Cycle 1
(April 4, 1984 Launch Date)

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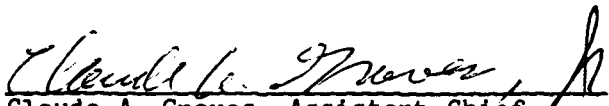
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Appendix A

SHUTTLE PROGRAM

STS-13 FLIGHT REQUIREMENTS DOCUMENT
APPENDIX A
LEVEL A GROUNDRULES AND CONSTRAINTS

OPERATIONAL FLIGHT PROFILE
CYCLE 1
(April 4, 1984 LAUNCH DATE)

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1.0 INTRODUCTION

This document defines the groundrules and constraints baselined by level II that were used in generating the operational flight profile (OFP) for the Space Transportation System-13 (STS-13). Section 2.0 presents a brief summary of the STS-13 flight. The level A groundrules and constraints currently baselined for STS-13 are presented in section 3.0.

2.0 STS-13 DESCRIPTION

STS-13 will nominally be a 6 day mission with launch from Kennedy Space Center (KSC) on April 4, 1984 at or near 10:05 a.m. EST, 15:05 Greenwich mean time (GMT). The purpose of the flight is to deploy the Long Duration Exposure Facility (LDEF) and rendezvous with the Solar Maximum Mission (SMM) satellite, repair it, and then redeploy it. If repair operations are not successful and the LDEF is deployed, the SMM will be stowed in the payload bay and returned to Earth.

FOREWORD

This document contains the approved groundrules and constraints to be used in generating the operational flight profile (OFP). Hardware development, software verification, and crew training should be consistent with the data presented within the Space Transportation System-13 (STS-13) OFP.

These Groundrules and Constraints and the Profile Summary of the STS-13 OFP are approved and controlled by the office of the Space Shuttle Program Manager (level II). This FRD appendix was baselined using the standard level II change process.

Document maintenance for this appendix and the OFP is assigned to the Mission Support Directorate (JSC/FA), Mission Planning and Analysis Division (JSC/FM).

for *R H Williams*
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ACRONYMS

AOA	abort once around
APU	auxiliary power unit
ATO	abort to orbit
c.g.	center of gravity
DTO	development test objective
EAFB	Edwards Air Force Base
EI	entry interface
EST	eastern standard time
ET	external tank
EVA	extravehicular activity
fps	feet per second
FSS	flight support system
FTSOD	flight test and supplementary objective document
GMT	Greenwich mean time
KSC	Kennedy Space Center
LDEF	Long Duration Exposure Facility
LVLH	local vertical local horizontal
M	Mach
MECO	main engine cutoff
MMU	manned maneuvering unit
MPS	main propulsion system
NASA	National Aeronautics and Space Administration
n. mi.	nautical miles
NOR	Northrup
OFP	operational flight profile

OMS	orbital maneuvering system
OV	Orbiter vehicle
PTI	programmed test input
RCS	reaction control system
RMS	remote manipulator system
RTLS	return-to-launch site
SMM	Solar Maximum Mission (satellite)
SODB	Shuttle Operational Data Book
SODS	Shuttle Operational Data Submittal
SRB	solid rocket booster
SSME	Space Shuttle main engine
STS	Space Transportation System
TAL	transatlantic abort landing

3.0 STS-13 FLIGHT DESIGN GROUND RULES AND CONSTRAINTS - LEVEL A

Groundrule number	Groundrule description	Groundrule definition	Ref.
3.1.1	Launch date	April 4, 1984	L
3.1.2	Launch time	approx. 10:05 a.m. EST (15:05 GMT)	L
3.1.3	Orbiter vehicle	OV-099	
	External tank	LWT-7	
	SRB	MWC	
	SRM motor	HPM	
3.1.4	Orbital Altitude Requirements		
	A. Post-OMS-2 orbit		
	(1) Range	Ha = 250 n. mi. 120 <= Hp <= 250 n. mi.	
	(2) I-Loads	Ha = 250 n. mi. Hp = 120 n. mi.	
	B. LDEF deploy orbit		J2
	(1) Nominal ascent	10 n. mi. below SMM 256/260 nominal 250/250 minimum Ha-Hp <= 10 n. mi.	
	(2) Non-nominal ascent	High as possible 200/200 n. mi. minimum Ha-Hp <= 10 n. mi.	
	C. SMM retrieve orbit	266/270 projected nominal 263/267 projected minimum	M
	D. SMM deploy orbit	285/285 desired	J1
	E. Minimum ATO orbit	105 n. mi.	
3.1.5	Inclination	28.50°	M

Groundrule number	Groundrule description	Groundrule definition	Ref.
3.1.6	Landing sites		M
	A. End of mission		
	(1) Prime	KSC, runway 15 (overhead approach, left turn).	
	(2) Weather alternate	EAFB, runway 22 (overhead approach, left turn).	
	B. RTLS	KSC, runway 15 (overhead approach, right turn).	
	C. TAL	Dakar, Senegal, runway 01 (overhead approach, right turn).	
	D. AOA		
	(1) Prime	EAFB, runway 17 (overhead approach, left turn).	
	(2) Weather alternate	NOR, runway 17 (overhead approach, left turn).	
3.1.7	Landing times	Lighted landings are desirable, but landings in darkness are permissible.	
3.1.8	Flight duration	Nominal = 143 hr	M
3.1.9	Flight crew	5	M
3.1.10	Cargo	LDEF SMM/FSS	M
3.1.11	Ascent profile	1. Direct insertion technique will be used.	

Groundrule number	Groundrule description	Groundrule definition	Ref.
3.1.11 (Conc'd)		2. Nominal OMS-1 will not be performed. 3. A 5 fps +x RCS ullage will be performed immediately following the nominal ET separation maneuver to facilitate the MPS dump and allow photography of the ET. 4. OMS-2 will be targeted to raise perigee to a value (between 120 and 250 n. mi.) dependent upon the phasing requirement at the launch time.	
3.1.12	Ascent shaping	Shape for nominal (no lofting bias) - direct insertion.	
3.1.13	Ascent mean winds	1. Performance estimated with April mean winds. 2. Winter seasonal I-loads designed with December mean winds. 3. Products generated with December mean winds.	
3.1.14	SRB bulk temperature	1. Performance estimated with 67 deg. F. 2. Winter seasonal I-loads designed with 63 deg. F. 3. Products generated with 63 deg. F.	

Groundrule number	Groundrule description	Groundrule definition	Ref.
3.1.15	SSME power level	Minimum 65% Maximum nominal 104% Maximum abort 104% Maximum for contingency abort 109%	L
3.1.16	OMS ballast for X c.g. control during aborts	Yes	
3.1.17	Pre-MECO OMS dump	May be utilized to protect the ET impact point and/or the 55 n. mi. minimum geodetic altitude post OMS-1.	
3.1.18	MECO targets	1. Nominal V, fps 26 019.7 gamma, deg 1.114 Alt., n. mi. 57 2. AOA/ATO V, fps 26 019.7 gamma, deg 1.114 Alt., n. mi. 57	
3.1.19	External Tank	1. ET footprint will be in the Pacific Ocean, within 25 to 127 n. mi. of the island of Hawaii. 2. MECO targets will be constrained to provide tracking of ET rupture and breakup events from ground sensors based in the Hawaiian Islands. Order of priority for tracking coverage will be: <ul style="list-style-type: none"> ● ET rupture event ● ET breakup 	

Groundrule number	Groundrule description	Groundrule definition	Ref.
3.1.20	Launch Window	<ol style="list-style-type: none"> 1. Launch window opening will occur when the target node is equal to 93.25 deg. (approx. in-plane time + 3 min.) to keep the ET rupture and breakup events within 127 n. mi. of the Hawaii tracking sensors. 2. Launch window closing will occur when the target node is equal to 90 deg. (approx. inplane time + 16 min.) to keep the ET impact footprint at least 25 n. mi. from Hawaii. 3. Must be acceptable for SMM phasing requirements based on a FD-2 LDEF deploy. 4. An MPS yaw steer allotment shall be maintained such that the launch window can be expanded to accommodate 360 deg. of phasing based on a FD-2 LDEF deploy. 5. First stage launch azimuth will remain constant throughout the 13 minute launch window. Other I-load sets will be available across the expanded launch window. 	

Groundrule number	Groundrule description	Groundrule definition	Ref.								
3.1.21	On-orbit cargo										
	A. LDEF operations										
	(1) LDEF deploy time	LDEF will be deployed on FD-2.									
	(2) LDEF release attitude	1. Gravity gradient stabilized. 2. Space end (H-end) along negative radius vector (away from Earth). 3. Earth end (G-end) along positive radius vector (toward Earth). 4. Port trunnion (row 9) along plus velocity vector.	J2								
	(3) Release state constraints	1. Error in LVLH angle (each axis) not to exceed 5 degrees. 2. Error in LVLH angular rate (each axis) not to exceed 0.025 deg/sec.	J2								
	(4) Thermal constraints in bay	<table><tr><th><u>Attitude</u></th><th><u>Max Time</u></th></tr><tr><td>+ZLV (bay to Earth)</td><td>Continuous</td></tr><tr><td>+Z-SI (bay to Sun)</td><td>120 min.</td></tr><tr><td>+Z-space (bay to space)</td><td>90 min.</td></tr></table>	<u>Attitude</u>	<u>Max Time</u>	+ZLV (bay to Earth)	Continuous	+Z-SI (bay to Sun)	120 min.	+Z-space (bay to space)	90 min.	J2
<u>Attitude</u>	<u>Max Time</u>										
+ZLV (bay to Earth)	Continuous										
+Z-SI (bay to Sun)	120 min.										
+Z-space (bay to space)	90 min.										
	(5) Plume impingement	The Orbiter separation from the LDEF shall be planned so as to minimize thruster plume impingement on the LDEF.	J2								

Groundrule number	Groundrule description	Groundrule definition	Ref.
3.1.21 (Conc'd)	(6) Status weight	21 528 lbs.	J2
	B. SMM		J1
	(1) Retrieval attitude	The SMM will be stabilized via MMU operations prior to Orbiter approach to grapple range.	
	(2) SMM reboost	Reboost to a higher altitude (285 n. mi. desired) if adequate STS performance is available and if LDEF is deployed.	
	(3) SMM return	If the repair of the SMM is unsuccessful, and the LDEF is deployed, the SMM solar panels will be jettisoned and the SMM will be safed, stowed for reentry, and returned.	
	(4) Release attitude	1. Solar inertial. 2. SMM solar panels toward Sun ± 5 deg.	
	(5) Release rates	1. Maximum Orbiter rates shall be $\leq .01$ deg/sec in each axis. 2. Tipoff rates induced by the Orbiter/RMS shall be $\leq .25$ deg/sec in each axis.	
	(6) SMM status weight	4956 lbs on-orbit.	
	(7) FSS status weight	8915 lbs.	
3.1.22	RMS operations	1. RMS will be used to deploy LDEF using the star-board grapple fixture.	

Groundrule number	Groundrule description	Groundrule definition	Ref.
3.1.22 (Conc'd)		2. RMS will be used to retrieve, berth, and deploy SMM using the original SMM grapple fixture.	
		3. OMS/RCS usage will be constrained by RMS operating limitations.	N
		4. Two ft. clearance must be maintained between individual payloads and/or Orbiter structure uniformly to a minimum of 6 in. when the trunnions are fully seated in the latches.	N
		5. Payload location in bay must allow for clearance of the payload grapple envelope as well as a minimum of 2 ft. clearance between the RMS upper and lower booms and Orbiter or payload.	N
3.1.23	Separation requirements	1. The low Z DAP/RCS jet select logic will be used when in close proximity ($R \leq 200$ ft.) to the payload to minimize the disturbance and contamination on the payload by Orbiter thruster activity.	N
		2. The payload must be within direct visual acquisition from release until the range is ≥ 200 feet.	N
		3. Establish an initial positive separation rate of at least 0.5 fps as soon as practical.	

Groundrule number	Groundrule description	Groundrule definition	Ref.
3.1.24	Rendezvous		
	A. Rendezvous time	Flight day 3	
	B. Rendezvous radar	1. SMM will be passive. 2. Rendezvous radar shall be active from its max acquisition range, except where the antenna is utilized for Ku-band communications. Its use during MMU free flight operations will be such that it is not hazardous to the MMU crewman.	
	C. PROX-OPS	1. Positive V-bar approach. 2. Low Z thruster mode used from 200 ft on in.	
3.1.25	EVA	1. Two 6-hr periods will be allotted for EVA. 2. It is desirable to perform EVA outside the South Atlantic anomaly region. 3. MMU fly over operations will begin at a range of 200 ft. with Orbiter in station keeping mode. 4. MMU fly over operations will be conducted in daylight.	
3.1.26	Consumable loading		
	A. Propulsive OMS:	On-orbit: 21 161 Disp. cont: 2 243 Trapped: 799 Margin (ballast): <u>861</u> Total: 25 064 lbs (full)	

Groundrule number	Groundrule description	Groundrule definition	Ref.
3.1.26 (Conc'd)		Aft RCS: 4 970 lbs. Fwd RCS: 2 446 lbs.	
	B. Non-propulsive	4 H ₂ tanks: 368 lbs. (100%) 4 O ₂ tanks: 3 124 lbs. (100%) 4 N ₂ tanks: 262 lbs. (100%) 2 NH ₃ tanks: 98 lbs. (100%) 3 APU fuel: 975 lbs. (100%) 3 APU H ₂ O: 424 lbs. (100%) 2 APU fuel pump H ₂ O: 42 lbs. (100%) 1 gas generator H ₂ O: 6 lbs. (100%) 4 potable H ₂ O tanks: 429 lbs. Tank A 7 lbs. (empty) Tank B 165 lbs. (full) Tank C 127 lbs. (75%) Tank D 127 lbs. (75%) 1 waste H ₂ O tank: 7 lbs (empty)	
		Crew provisions: Std. 5 persons 7 days	M
3.1.27	Entry angle-of-attack profile (nominal, ATO, AOA, TAL)	Standard 40 degrees (STS-6 profile)	M
3.1.28	Allowable c.g. at Mach = 3.5 (includes 1 in. X and 0.5 in. Y uncertainty)	$1084 \leq X \leq 1108$ $-1.5 \leq Y \leq 1.5$	M
3.1.29	Desired c.g. for flight tests (includes 1 in. X uncertainty)	From EI to M 3.5: $1084 \leq X \leq 1108$	M
3.1.30	Crossrange	Nominal prime: 693 n. mi. AOA: 719 n. mi. Maximum: 736 n. mi. TAL: 525 n. mi.	

Groundrule number	Groundrule description	Groundrule definition	Ref.
3.1.31	Entry RCS allowance	(a) Nominal (with PTI's): 1800 lbs. (b) Nominal or abort (w/o PTI's for Mach > 7): 1550 lbs.	
3.1.32	References		
	A. Aerodynamics	1. Ascent a. IVBC-3 Aerodynamics Reference, JSC Memo ET3/8301-1, Jan., 1983. b. IVBC-3 Aerodynamics Tapes, JSC Memo ET3/8301-18, Feb., 1983.	
		2. Descent Aerodynamics Design Data Book, Vol. I, SD72-SH-0060-1L, Oct. 1978, as modified by STS-4A Deltas, JSC-18699, Oct., 1982.	
	B. Flight software	Build 21	
	C. First-stage engine out alpha flight corridor	SODS J-719, Add 2 July 1983.	
	D. General vehicle constraints	SODB, Vol I, JSC-08934, Rev. B, Feb. 1980, as of Amendment no. 127, Nov. 6, 1981.	
	E. Detailed test objectives	1. FRD, JSC-17462-13, June 1983. 2. FTSOD, JSC-16725, April 26, 1983.	
	F. C.G. constraints	FRD, JSC-17462-3, June 1983.	

Groundrule number	Groundrule description	Groundrule definition	Ref.
3.1.32 (Cont'd)	<p>G. Initialization data</p> <ul style="list-style-type: none"> -Mass properties -SRB thrust profile -MPS budget -SSME tag values <p>(I-load generation)</p> <ul style="list-style-type: none"> -SSME Assessment Isp and Thrust (Product Generation) -SSME Contingency Engine Data (ARD/ Console Use) -Nominal and Abort FPR -Q, Qα vs. Mach Constraints <p>H. Ascent winds</p> <p>I. First-stage heating constraints (Q-alpha flight corridor)</p> <p>J. Payload</p> <p>K. Descent environment</p> <p>L. STS Flight Definition and Requirements Directive</p>	<p>SODS J-722, June 23, 1983.</p> <p>Probabilities for Cape Kennedy Wind Component, NASA TMX 64771, Apr. 16, 1973.</p> <p>SODS J-689 Add 3B, Aug. 6, 1982.</p> <ol style="list-style-type: none"> 1. Solar Maximum Repair Mission Payload Integration Plan JSC-14082, Basic-Change 5, May 1983. 2. LDEF Payload Integration Plan, JSC-14012, Basic-Change 3, Apr. 1983. <p>Four-D Global Reference Atmospheric Model (April).</p> <p>JSC-07700, Change 29 Aug. 1, 1983.</p>	

Groundrule number	Groundrule description	Groundrule definition	Ref.
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3.1.32 (Conc'd)	M. STS-13 Flight Require- ments Document	JSC-17462-13, Baseline July 1983.	
	N. Standard Groundrules and Constraints. Level B	JSC-18504, To be published.	

4.0 CHANGE CONTROL MANAGEMENT PROCEDURES FOR FLIGHT REQUIREMENTS DOCUMENTS

Approval and control of this document will be in accordance with Mission Integration Control Requirements and Procedures, JSC-13995.